



Video Transmission Using Cellular Gateways

By Greg Santos,
Senior Application Engineer
Longwatch, Norwood, MA

1.0. Overview

Historically, monitoring and control of remote sites required very little data bandwidth. Remote sites typically had a few I/O and communicated over voice-grade phone lines. After the advent of PLCs and RTUs, many remote operations had to improve communications to go along with the upgrade to these digital devices. However, even PLCs and RTUs sometimes do not have enough data bandwidth to perform as needed. Today, operators are asking for more capabilities in their remote operations, such as Video Surveillance and remote Access Control.

In a modern control system with high speed networks, video surveillance for security, process control and automation purposes can use the existing plant network to interface with Supervisory Control and Data Acquisition (SCADA) systems and HMIs, such as Wonderware, Rockwell and GE Fanuc. However, many control systems today do not utilize high speed networks and still communicate via slower connections.

While some video systems, such as the Longwatch Video System, are designed for low bandwidth networks, there are still many remote sites, Figure 1, that have insufficient infrastructure, obsolete technologies or high levels of proprietary technology, making it difficult for even Longwatch to operate effectively. These include DC telephone circuits, tone (FSK) communications, proprietary radio networks, extremely slow networks (300 bps), and others.



Figure 1: Remote sites, such as this water tower, are ideal locations for using cellular communications to transmit video surveillance images.

There is a very short and expensive list of upgrade paths that will result in a network that will be sufficient for video surveillance applications. While all upgrade options will require some level of engineering, the simplest and fastest upgrade is to install a Cellular Gateway. With data rates up to 2 Mbps, a cellular connection can handle most remote site communications needs.

The term Cellular Gateway refers to a device that acts as an interface between a control room computer or LAN and a remote site through a cellular data connection. These gateways can provide high performance wireless TCP/IP data communications via cellular networks for connecting remote sites and devices. This communication pathway is secure and “always on,” allowing for on-demand transfer of data to both Ethernet and/or serial devices. Setting up a cellular gateway is often simpler and much less expensive than installing a point-to-point wireless system. Table 1 illustrates the main steps in configuring a Longwatch video system via a cellular gateway.

Table 1: Cellular Gateway Implementation Checklist

- Determine which sites will require a Cellular Gateway device.
- Determine which cellular providers are available in your area. Use <http://www.wirelessadvisor.com>
- Find cellular towers located in your area to estimate operability. Use <http://www.antennasearch.com/>
- Perform preliminary Site Surveys at your target sites.

- Select the Cellular Service Provider.
- Procure Equipment, including Cellular Gateway, Antenna, Lighting Suppression, Cabling, and mounting hardware.
- Activate the hardware with the Service Provider you have chosen.
- Install/Provision the gateway and test communications.
- Test and tune communication from the Video Control Center location.
- Configure the Longwatch Video Control Center for proper communication.

2.0. Network Layout

Within the Longwatch system, multiple video cameras at a remote site connect to a Video Engine which archives all live video data onto an on-board hard drive while simultaneously transmitting video data to the control room at a bandwidth and timing selected by the operators. For example, although the system may be acquiring video data at 80 kbits/sec from a camera, the Video Engine may be configured to send data at a lower rate, say 5 or 10 kbits/sec. The transmission rate depends on the number of cameras that need to transmit at the same time, and the ability of the cellular connection to accommodate the bit rate.

The cellular gateway device resides at the same location as the Video Engine, Figure 2. Once the cellular gateway is configured, it will be assigned a unique, static IP address that is publicly accessible. With built in port-forwarding capabilities, the gateway is able to act as a portal into the remote network of the Video Engine. This allows the Video Control Center (VCC) in the control room to access the remote network in order to command the Video Engine, while simultaneously allowing the Video Engine to send data back to the VCC.

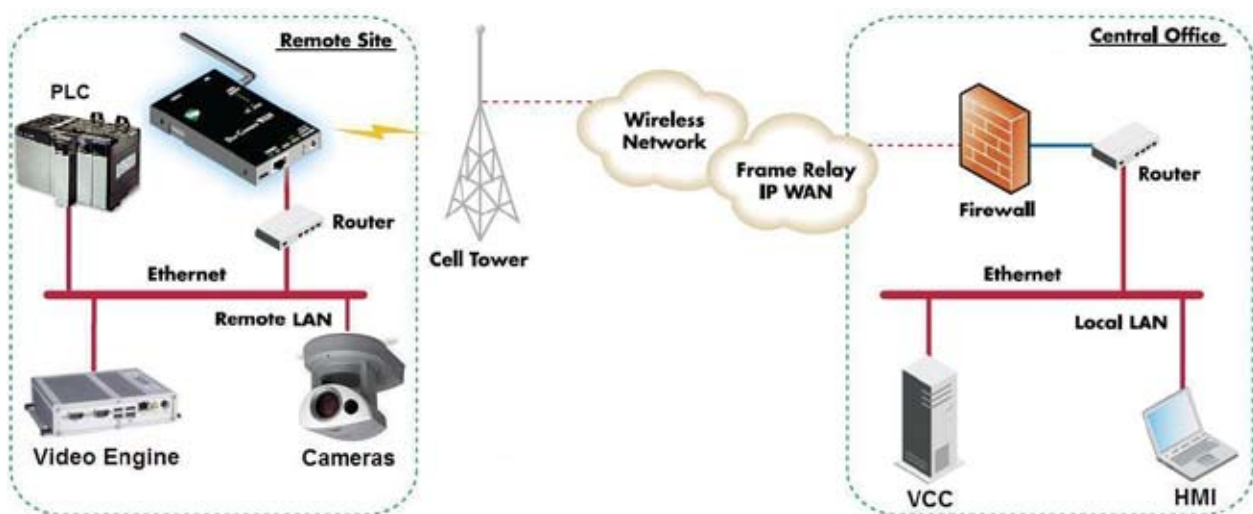


Figure 2: Network layout for a Longwatch Video Surveillance System. Multiple cameras, PLC, door access switches and other hardware connect to a Longwatch Video Engine. The Video Engine transmits video images and receives instructions via a cellular network. At the control room, incoming video packets go through a firewall and router onto the local LAN, then to the Video Control Center, where incoming packets are reassembled into a video stream. Videos can be played on the local HMI, such as a Wonderware or GE Fanuc system.

Over this connection, operators at an HMI station can pan, tilt and zoom remote cameras, request playback of archived images, and place one or more cameras into “live mode,” where they transmit real-time video.

In many applications, there is no need to watch high-resolution images from all cameras at all times. Instead, such systems can send images on a regularly-scheduled basis at lower resolution. If an intrusion alarm, process alarm, or a scheduled event occurs—such as taking a sample from a tank or lagoon—the system or the operator can give all the available bandwidth to a single camera so that faster, higher resolution images can be sent live.

Many modern cameras and the Longwatch system are able to detect anomalies in the video image, such as an intruder, a wayward crane hook (Figure 3) or a steam leak, which can trigger an alarm. With such capabilities, there is no need for an operator to constantly monitor cameras; if an alarm occurs, the system can be configured to alert the operator and automatically switch to live viewing mode.

Because all live video is archived, operators can “go back in time” and ask to see video that occurred ten seconds, ten minutes or ten hours before an event. This capability makes it unnecessary for the system to transmit high resolution video at all times.

Cellular connections, however, are not 100% reliable. Fortunately, Longwatch remote systems can operate in stand-alone mode if a cellular connection is lost, continuously monitoring alarms and capturing and archiving video without a network connection. When the cellular connection is eventually re-established, operators can view video taken during the outage as well as review any remote alarms or conditions that may have occurred.



Figure 3: Modern digital video cameras and the Longwatch system can identify anomalies in the image, sound an alarm, and switch to live video mode. Here, the Longwatch system spots a swinging crane hook passing its field of view, puts a red “box” around it, and tracks it across the image. With capabilities like this, there is no need to send video continuously over a cellular connection.

3.0. Network Security

Security is a consideration for virtually everyone deploying in remote environments today. Advantages built into cellular networks make the data communications inherently more secure than many other types of wireless networks. However, when considering a remote wireless deployment, one should be concerned not only with securing the data, but also with securing the management of the remote devices. You have the ability to address each of these issues with the following features:

- Cellular data networks inherently provide Over-The-Air (OTA) encryption to protect the wireless data path.
- Cellular gateways can be configured using Access Control Lists for IP filtering to allow only certain incoming traffic. Network Address Translation (NAT) support is also provided to hide private currently connected IP addresses.

- Pass-through capabilities via TCP/UPD port forwarding are also incorporated in most cellular gateway devices, thus restricting access to specific ports.
- Secure management of the cellular gateway device can be provided via passwords, by blocking certain services such as telnet, and by using HTTPS and SSH to manage the device. Optionally, the data traffic to cellular gateway management interface can be secured using SSL.
- Additional end-to-end security can be implemented between the remote site and the subscriber's central office by using IPsec encryption. IPsec is fully supported and integrated in the Longwatch family of products.

4.0. Cellular Service

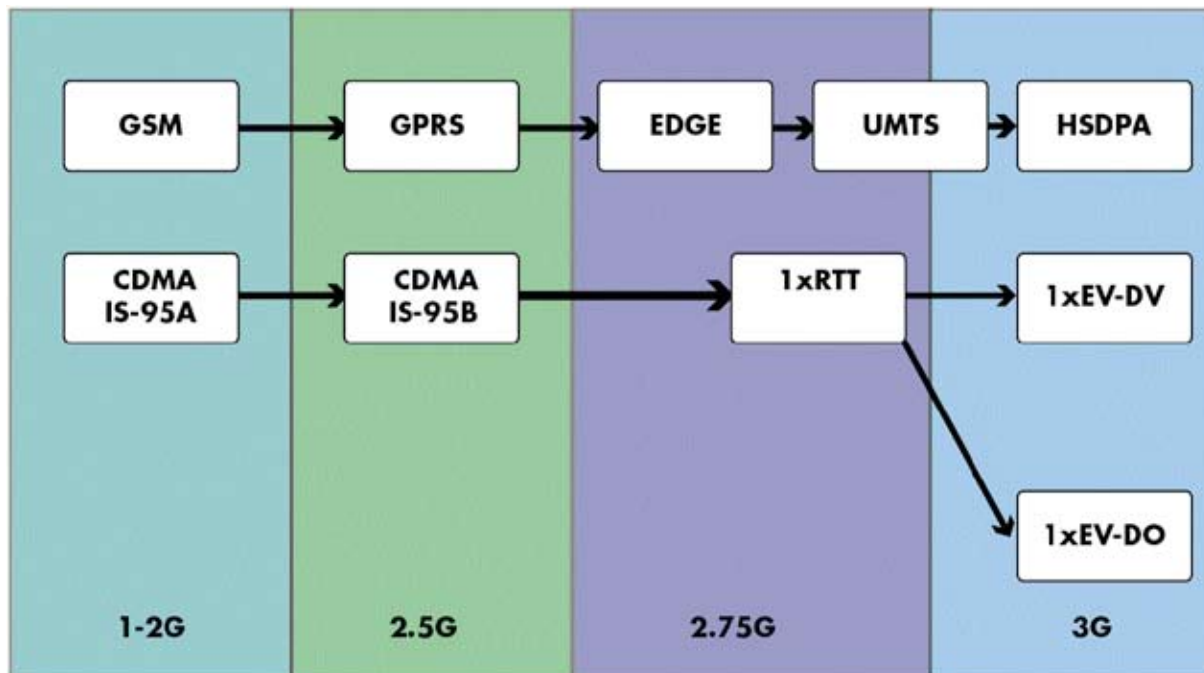
Cellular service carriers can be divided into one of two categories: GSM or CDMA.

GSM (Global System for Mobile Communications) is the dominant global standard for wireless communications. Wireless carriers such as T-Mobile and AT&T Wireless deliver GSM in North America. A listing of international carriers can be obtained on the GSM World website at <http://www.gsmworld.com>.

CDMA (Code Division Multiple Access) is a wireless technology delivered in the U.S by carriers such as Sprint PCS and Verizon Wireless. Coverage maps for CDMA carriers are available at <http://www.cdg.org>.

Both GSM and CDMA have evolved with technology improvements in what is called "Generations," or "G" (i.e., 1G, 2G, and 3G), with fractional Generations recognized for the second Generation (i.e., 2.5G, 2.75G). With each technology improvement comes higher data rates and network enhancements. Table 2 shows the evolution path for GSM and CDMA. Please note that 1xEV-DV deployment is currently stalled and has, for the most part, been superseded by 1xEV-DO.

Table 2: Cellular Data Technology Progression



Both GSM and CDMA support different data transfer technologies. These technologies offer different data transfer throughput and speed capability. The cellular gateway device will have the ability to support one or more of these data transfer standards depending on the cellular carrier you chose. Table 3 shows data transfer rates, but note that the “Typical Throughput” column accounts for real-world scenarios where wireless throughput is further reduced due to network congestion, fading, weather conditions and noisy environments.

Table 3: Estimated Data Transfer Rates

Technology	Generation	Connection Type	Theoretical Max Kbps	Carrier Max Kbps	Typical Throughput Kbps
GSM	1G	Circuit	—	9.6	—
CDMA	2G	Circuit	—	14.4	—
GSM GPRS - Class 6	2.5G	Packet	64.4	40.6	15-30
GSM GPRS - Class 10	2.5G	Packet	86.2	40.6	20-40
GSM GPRS - Class 12**	2.5G	Packet	86.2	40.6	20-40
CDMA - 1xRTT	2.75G	Packet	307	153	60-80
GSM Edge - Class 2	2.75G	Packet	118	118	40-80
GSM Edge - Class 10	2.75G	Packet	237	237	80-160
GSM Edge - Class 12**	2.75G	Packet	237	237	80-160
UMTS (W-CDMA)	3G	Packet	384	384	200-300
1xEVDO (CDMA2000)	3G	Packet	>2000	>2000	400-700
HSDPA	3G	Packet	>2000	>2000	400-700

***Same overall performance as Class 10 with improved uplink performance.*

Cost is an important factor when deciding whether to deploy a cellular gateway solution. Fortunately, cellular data plan costs have fallen significantly, creating a more compelling reason to switch to cellular data networks for remote device communications. In addition, cellular gateways have the advantage of maintaining an “always-on” connection without paying for the airtime; customers pay only for the data they actually send over the wireless connection.

Wireless carriers typically charge customers by the number of Megabytes (Mb) or Kilobytes (Kb) transmitted per month. These rate plans vary from carrier to carrier but typically involve several rate plan options structured in the following format:

\$X per month for up to Y Mb data + \$Z per Kb exceeding Y

Other rate plan options are available depending on the specific carrier and application usage profile. These plans may include provisions for unlimited usage, data pooling (usage spread across a number of devices), or time-of-day discounts. Monthly charges of \$7.99 for 1MB to \$69.99 for unlimited data access are typical rates, but can be more or less expensive depending on data usage plans.

If cost is a consideration, video transmission can be configured so that images from remote sites are sent at lengthy intervals; say, a single image from the camera sent once every five minutes, Figure 4. This gives the operator an updated view of the remote site without utilizing large amounts of bandwidth. If an alarm occurs, video can instantly change from sending these static images to live streaming video transmission. In addition, the remote video archiving capability of Longwatch ensures that all video is available on request.



Figure 4: Instead of watching live video from these 24 remote sites, this water company schedules each site to send a short video clip every five minutes. If any site detects an intruder or an alarm, it can switch to live video immediately.

5.0 IP Addressing

A typical Longwatch network is comprised of one Video Control Center (VCC) component and one or more Video Engines. The VCC initiates communication to each Video Engine which in turn responds with the requested data. Therefore, the Video Engine portion of the Longwatch network requires a routable or “reachable” fixed IP address. To accomplish this, the service plan must provide a public IP Address that is either static in nature or utilizes a Dynamic DNS service for name resolution.

Public IP addresses are generally reachable by anyone on the internet. These addresses are most commonly assigned in a dynamic format, changing after an interval defined by the given service provider. Static IP addresses are also available but tend to be more expensive because wireless carriers have a limited number of static addresses they can issue.

The Longwatch Video Control Center uses static IP addresses or static name servers to communicate to each of its configured Video Engines. Therefore, before committing to your cellular service plan, it may be advantageous to request a static IP address from the vendor. This allows for easier installation and configuration. If a static IP address is not available or simply costs too much, it’s possible to utilize a Dynamic DNS service.

6.0. Service Testing (Site Survey)

Completing a full site survey prior to integration is a necessary step in ensuring the successful implementation of the cellular gateway device. A site survey consists of measuring the Radio Frequency (RF) signal strength of the cellular provider's network you have chosen. This series of tests must be performed on the site of final installation using one of the following devices:

- Cellular Gateway (Recommended)
- Cellular Phone

How to use a cell phone for a basic site survey: <http://www.wpsantennas.info/pdf/testmode/FieldTestModes.pdf>

- Cellular AirCard

It is recommended to obtain a cellular gateway device similar to the model which will be used prior to surveying the site. This will ensure the most accurate site survey possible and will give you the ability to become familiar with the device prior to integration.

The best throughput comes from placing the device in an area with the greatest Received Signal Strength Indicator (RSSI). RSSI is a measurement of the Radio Frequency (RF) signal strength between the base station and the mobile device expressed in dBm. The better the signal strength, the less data retransmission and, therefore, better throughput.

RSSI information is available from several sources on the cellular gateway device. For example, on a Digi Cellular Gateway device:

1. The LEDs on the device give a general indication (1-4 "bars"), where:
 - -101 dBm or less (0-1 LED) = Unacceptable coverage
 - -100 to -91 dBm (1-2 LEDs) = Weak Coverage
 - -90 to -81 dBm (2-3 LEDs) = Moderate coverage
 - -80 dBm or greater (4 LEDs) = Good Coverage
2. The Digi device's built-in local user interface provides:
 - Access via an HTTP browser (navigate to it with: Digi web interface > Information > System Info > Mobile)
 - A Command Line Interface (CLI) command "display mobile" via telnet, SSH or local serial port connection (via HyperTerminal, TeraTerm or other emulation package) to the Digi cellular router.
3. Digi Connectware Manager (Server Platform) can display the value in dBm via its System Information screen.

7.0. Going Cellular

Cellular communications offer flexibility, high bandwidth and cost effective solutions for companies looking to expand their networking capabilities or installing video surveillance equipment in remote locations. Because of the extensive wireless cellular backbone already in place across North America and much of the world, cellular devices rarely encounter reception or line-of-sight related issues that plague other wireless networking systems.

Cellular gateways have the ability to be moved from one location to the next without fear of network upset. This makes cellular networking ideal for those looking for adaptable, deployable video solutions that may be used for surveillance of intermittent problem areas.

Cellular gateways offer extremely high bandwidth capabilities for a wireless networking product. The most current technologies allow for data rates in excess of 2 Mbps, allowing users to transfer large amounts of data quickly and easily. Cellular data encryption and routing capabilities built into most cellular devices give users the security they need to protect their assets and data. With easy integration and flexible cost, cellular networking is a perfect solution for new installations as well as the expansion of existing network infrastructures.

8.0. Cellular Solution Resources

Establishing a connection to a remote Video Engine and allowing access to that device and others on a remote network involves two important pieces:

- Hardware: A cellular gateway product such as the Digi Connect WAN or Airlink Raven-E.
- Cellular Service Plan: Acquiring a monthly service plan from a wireless carrier.

Some hardware distributors sell devices but do not offer activation services, while others bundle activation with the hardware purchase. Buying a pre-activated wireless product requires the customer to contact a wireless carrier to identify a proper rate plan and acquire a public IP connection.

Solution Providers

Solution providers that offer both hardware and wireless service activation can help simplify this process for customers. Longwatch has had success with the following distributors:

1. Industrial Network Solutions

16415 Addison Road, Suite 550, Addison, TX 75001

Phone: 1 972 248-7466

Fax: 1 972 248-9533

<http://www.industrialnetworking.com/>

2. Express Systems & Peripherals

640 Herman Road, Suite 5, Jackson, NJ 08529, USA

Phone: 1 800 222-0172

<http://www.express-inc.com/>

3. Ingram Micro U.S.

1600 E. St. Andrew Pl, Santa Ana, CA 92799-5125, USA

Phone: 1 800 456-8000

<http://www.express-inc.com/>

4. Source Inc.

10975 Benson, Suite 350, Overland Park KS 66210, USA

Phone: 1 913 638-4243

Fax: 1 913 322-3683

<http://www.sourceincusa.com/>

5. USAT Corp.

P.O. Box 9334, Chapel Hill NC 27515-9334, USA

Phone: 1 888 550-8728

Fax: 1 913 322-3683

<http://www.usatcorp.com/products/>

9.0. Wireless Carriers

Wireless carriers offer cellular services in either GSM or CDMA format. Below you will find some of the more prevalent U.S. cellular carriers. For more information about vendors in your area, visit: <http://www.wirelessadvisor.com>

- AT&T Wireless (GSM) - U.S.
- Broadpoint (GSM) – U.S.
- Sprint (CDMA) - U.S.
- Verizon Wireless (CDMA) U.S., Puerto Rico
- Rogers Wireless (GSM) - Canada
- Midwest Wireless (CDMA) - U.S.
- Alltel Wireless (CDMA) - U.S.
- T-Mobile (GSM) - U.S.
- Cellular One (GSM) - U.S.
- Bell Mobility (CDMA) – Canada

Glossary

FSK	Frequency Shift Keying
VCC	Video Control Center
LVE	Longwatch Video Engine
OTA	Over The Air
NAT	Network Address Translation
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
GSM	Global System for Mobile Communications
CDMA	Code Division Multiple Access
EV-DO	Evolution Data Optimized
EV-DV	Evolution Data Voice
RF	Radio Frequency
RSSI	Received Signal Strength Indicator

10.0. About Longwatch

Founded in 2004 by a team of industry veterans, Longwatch, Inc. is dedicated to enhancing the safety and security of the Nation's water, utility and energy distribution systems by delivering a powerful, yet cost-effective solution.

The Longwatch solution is designed to deliver real-time video surveillance of remote facilities over existing SCADA communication networks. This proprietary, patent-pending technology will dramatically improve an operator's ability to monitor and verify alarms at remote sites utilizing existing communication infrastructures.

Longwatch, Inc.

520 Providence Highway
Norwood, MA 02062 USA
Toll Free: 877-LONGWATCH
Phone: 781-255-7400
Fax: 781-255-7414

support@longwatch.com

www.Longwatch.com